Skinner Lake AGNPS

Comparison of Pre-Treatment and Post-Treatment Sediment and Nutrient Loading

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INTRODUCTION

From 1978-1982, the Noble County Soil and Water Conservation District participated in a project to improve the water quality of Skinner Lake. Funds were supplied through the Environmental Protection Agency (EPA) Clean Lakes Program. The project was designed to reduce soil erosion in the watershed, construct a sediment basin/nutrient filter, improve the trophic condition of the lake, and consider the improvement of wetlands around the lake. The preliminary study, completed in 1982, evaluated the impact of the land treatment in the watershed which was applied to satisfy the first objective, the reduction of sediment bound pollutants.

In 1989 a follow-up study was developed jointly by the Indiana Department of Natural Resources (IDNR), Division of Soil Conservation, the Noble County Soil and Water Conservation District and EPA. EPA funds were matched with an IDNR Lake Enhancement grant to complete a more detailed pre and post condition evaluation of the original project and reconstruct the sediment basin.

Assessing the effectiveness of the land treatment using the Agricultural Non-Point Source Pollution Model (AGNPS) model is part of the follow-up study. The following report will summarize the results of this effort.

Site Description

Skinner Lake is a 122 acre natural lake located three miles east of Albion in Noble County, Indiana. It lies within the Steuben Morainal Lake Area in northeast Indiana. The lake's large watershed (9,230 acres) is characterized by gently rolling hills, scattered forests and agricultural row crops. Most of the lake's shoreline is developed.

Skinner Lake lies in the Elkhart River South Branch drainage area. Northeast of Skinner Lake (1/2 mile) is Sweet Lake, a natural lake that drains into Skinner Lake. Rimmel Ditch drains 82% of the watershed. Much of the area along Rimmel Ditch was originally wetlands. Several smaller intermittent ditches also drain into the lake.

Skinner Lake thermally stratifies during the summer. The maximum depth is 32 feet and the average is 14 feet. The Indiana Department of Environmental Management calculated the

Eutrophication Index to be 45, a class III lake in 1986. Most of the bottom material is organic muck but some areas are sand and marl. (Pearson 1980)

PROJECT HISTORY

Former 4th District U.S. Representative Ed Roush was instrumental in setting up a federal program to aid in the restoration of lakes where soil erosion and sedimentation problems existed. Roush and his staff studied several lakes in the 4th District and finally chose Skinner Lake as the site for a demonstration project. Skinner Lake was selected due to its large watershed, erosion and sedimentation problems and public access. The Noble County Soil and Water Conservation District accepted a proposal from Roush to administer the demonstration project. The project included a $400,000 matching grant through the EPA Clean Lakes Program.

The Soil Conservation Service (SCS) prepared conservation plans with the landowners in the watershed. The plans included those practices most effective in slowing down the erosion and sedimentation process. Land treatment practices consisted of water and sediment control basins, grassed waterways, conservation tillage, pasture and hayland planting, structures and diversions. (Figure 1).

Due to the success of the land treatment project an additional $60,000 of grant money was allocated to the project in 1981 to install additional soil conservation practices.

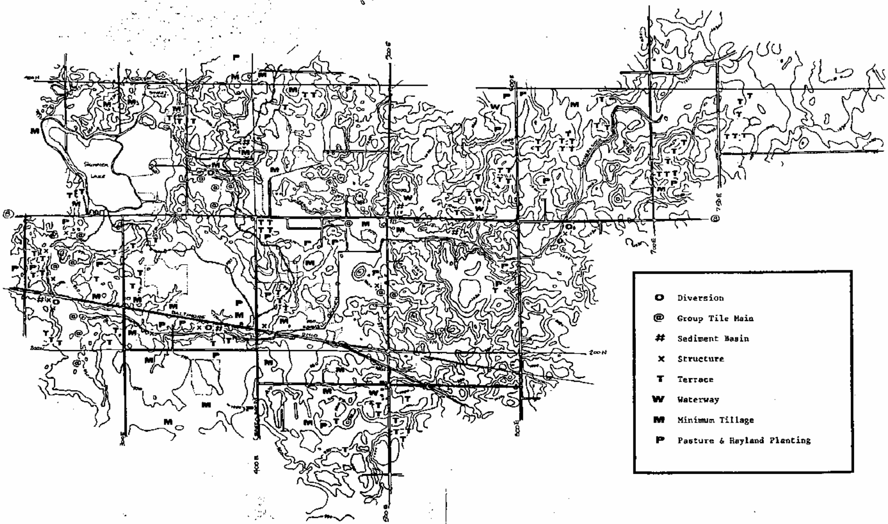
AGNPS MODEL

The Agricultural Non-Point Source Pollution Model (AGNPS) was developed by the Agricultural Research Service (ARS) in cooperation with the Minnesota Pollution Control Agency and the SCS. The model was developed to analyze and provide estimates of runoff water quality from agricultural watershed ranging in size from a few hectares to upwards of 20,000 hectares.

AGNPS is event based. The model simulates runoff, sediment, and nutrient transport from agricultural watersheds. The nutrients considered include nitrogen (N) and phosphorus (P), both essential plant nutrients and major contributors to surface water pollution. Basic model components include hydrology, erosion and sediment and chemical transport. The model also considers point sources of sediment from gullies and inputs of water, sediment, nutrients and chemical oxygen demand (COD) from animal feedlots, springs and other point sources. COD is a measure of the oxygen required to

Figure

Figure 1



O	Diversion
@	Group Tile Main
#	Sediment Basin
x	Structure
T	Terrace
W	Waterway
M	Minimum Tillage
P	Pasture & Hayland Planting

oxidize organic and oxidizable inorganic compounds in water. It is an indicator of pollution.

METHODS

As stated previously AGNPS is event based and can only be run for a single storm event. Because of this annual yields of runoff, sediment and nutrients from the modeled watershed cannot be calculated. The Skinner Lake comparison used a 3.9 inch rainstorm with an intensity of 90 foot-tons per acre inch.

The 9,230 acre watershed was divided into 40 acres cells a total of 257 cells were required to cover the watershed area. A few of the cells were sub-divided into four ten acre cells to examine them more extensively. For each of the cells in the Skinner Lake watershed, 22 separate parameters were determined. The following is a description of each of those parameters.

Cell Number: Each cell in the watershed is identified by a number. The cells are numbered consecutively from the cell in the northwest corner proceeding from west to east southward.

Receiving Cell Number: The number of the cell into which the most significant portion of the runoff drains. Drainage direction is determined by cell topography.

SCS Curve Number: The runoff number or hydrologic soil-cover complex number used in the Soil Conservation Service equation for estimating direct runoff from storm rainfall. Various curve numbers can be used for different landuse conditions. If more than one landuse condition exists within a cell, an average weighted value was used. A constant moisture condition of II was used to keep the analysis consistent.

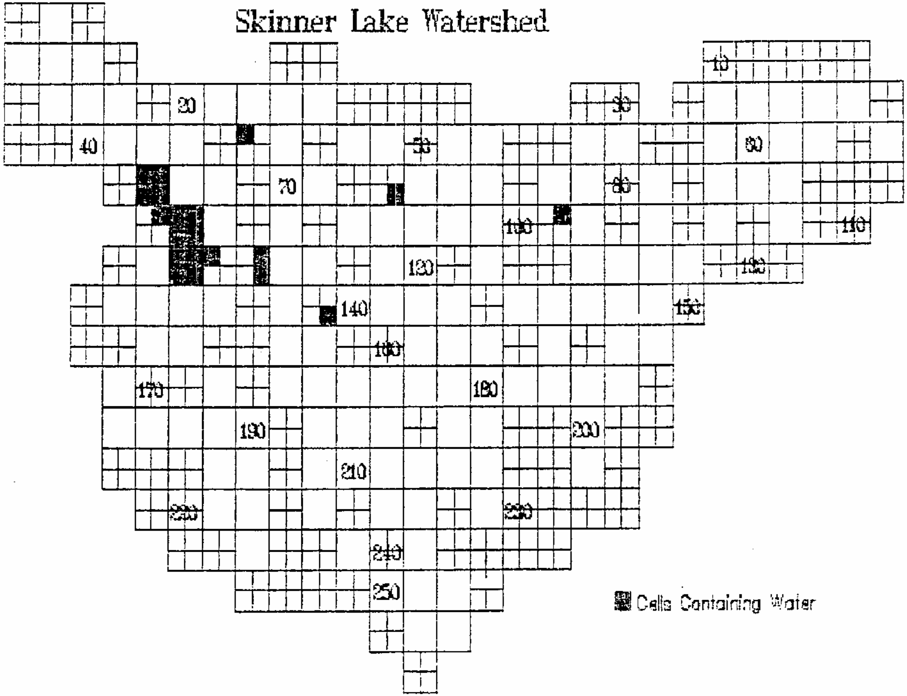
Land Slope: The major slope, in percent rise, of the cell. An average slope was determined if the cell was irregular.

Slope Shape Factor: An identification number used to indicate the dominant slope shape of the cell: 1, a uniform slope; 2, a convex slope; and 3, a concave slope.

Field Slope Length: Field slope length was determined using information from the Noble SCS Office and information from the AGNPS manual.

Channel Slope: The average slope, in percent, of the channel or channels. This was obtained from topography maps.

AGNPS CELL LAYOUT
Skinner Lake Watershed



Channel Sideslope: The average sideslope, in percent, of the channel or channels in the cell.

Manning Roughness Coefficient for the Channel: The roughness of the channel influences the flow velocity. The higher the roughness coefficient the higher the erosive power of the water. The value varies between zero and one, with one being most severe.

Soil Erodibility Factor: The K- factor used in the Universal Soil Loss Equation (USLE), obtained from the SCS soils information.

Cover and Management: The C-factor used in the USLE. Numbers are chosen to consider the worst case condition such as fallow or seedbed periods. Values range from 1.0 for conventional tillage to 0.01 for residential and 0 for water and wetlands.

Support Practice Factor: The P-factor used in the USLE. This factor is used to represent conservation practices installed on the land.

Surface Condition Constant: A value based on land use at the time of the storm to make adjustments for the time it takes overland runoff to channelize.

Cell Aspect: A single digit designating the flow of water from each cell.

Soil Texture: The major soil texture found within each cell was characterized as either water, sand, silt, clay, or peat by using the Noble County Soil Survey.

Fertilization Level: A single digit designation of the level of fertilization on the field. For high fertilization levels 3 is input, medium 2, low 1, and none is 0.

Fertilizer Availability Factor: The percentage of fertilizer left in the top half inch of soil at the time of the storm. The worst case would be if no fertilizer was incorporated into the soil then a factor of 100% would be entered. Percentages were determined using the AGNPS manual tables.

Point Source Designator: A single digit designator of point sources in the cell, such as feedlots, springs, and waste treatment plants

Gully Source Level: An estimate can be made for the tons of gully erosion occurring in a cell. The value will then be added to the total amount of sediment eroded in the cell.

<u>Chemical Oxygen Demand (COD) Factor:</u> A value for the COD concentration from the cell, based on landuse in the cell. COD factors were calculated using table 8 in the AGNPS manual.

<u>Impoundment Factor:</u> A factor indicating the presence of an impoundment terrace system within a cell. Zero would indicate no terrace in the cell, any other number would indicate the number of impoundments in the cell up to a maximum of 13.

<u>Channel Indicator:</u> A single digit indicating the presence of a defined channel within the cell: 0 denotes no defined channel, any other number indicates the number of channels in the cell.

All information describing general AGNPS perameters was taken from Young ET.AL. (1987).

PRE-TREATMENT REVIEW

Data representative of the conditions before watershed land treatment was entered into the AGNPS program. The watershed was calculated to be 9,230 acres, each cell was 40 acres resulting in 257 cells. The storm event used was 3.9 inches with a storm energy intensity value of 90. Table 1 is a summary of the output data.

TABLE 1

Values at Watershed Outlet

Runoff Volume	1.8 inches
Peak Runoff Rate	2,621 cfs
Total Nitrogen in sediment	1.28 lbs/acre
Total Soluble Nitrogen in Runoff	2.15 lbs/acre
Soluble Nitrogen Concentration in runoff	5.16 ppm
Total Phosphorous in Sediment	0.64 lbs/acre
Total Soluble Phosphorus in runoff	0.43 lbs/acre
Soluble Phosphorus Concentration in runoff	1.04 ppm
Total Soluble chemical oxygen demand	56.0 lbs/acre
Soluble chemical oxygen demand concentration in runoff	134 ppm

POST TREATMENT REVIEW

After land treatment practices were installed, data representing the changes was entered into the program. The 9,230 acres watershed size did not change, nor did the cell size. The rainfall in inches (3.9) and intensity value of 90 remained the same. Table 2 is a summary of the post treatment output.

TABLE 2

Values at Watershed Outlet

Runoff Volume	1.7 inches
Peak Runoff Rate	2140 cfs
Total Nitrogen in Sediment	2.89 lbs/acre
Total Soluble Nitrogen in Runoff	1.87 lbs/acre
Soluble Nitrogen Concentration in Runoff	4.80 ppm
Total Phosphorus in Sediment	1.45 lbs/acre
Total soluble Phosphorus in Runoff	0.37 lbs/acre
Soluble Phosphorus concentration in Runoff	0.95 ppm
Total Soluble Chemical Oxygen Demand	53.98 lbs/acre
Soluble Chemical Oxygen Demand Concentration in Runoff	138 ppm

DISCUSSION

Side by side comparison of the output data shows an improvement in the post treatment results. Table 3 shows the side by side estimates for loadings to Skinner Lake generated by the AGNPS model.

TABLE 3

Loadings to Skinner Lake (lbs)

AGNPS Parameter	Pre BMP	Post BMP	Change	% Change
Sediment Yield[1]	12,508.9	9,468.6	-3,040.3	-24.31
Sediment P	21,697.9	17,037.7	-4,660.2	-21.48
Sediment N	43,330.9	34,152.4	-9,178.5	-21.18
Soluble P	3,970.6	3,349.8	-620.8	-15.63
Soluble N	19,725.1	17,217.0	-2,508.1	-12.72
Runoff[1]	1,370.1	1,276.6	-93.5	-6.83
Total P	25,668.5	20,387.5	-5,281.0	-20.57
Total N	63,056.0	51,369.4	-11,686.6	-18.53

[1]Note: All quantities are in pounds except Runoff (acre-ft.) and Sediment Yield (tons).

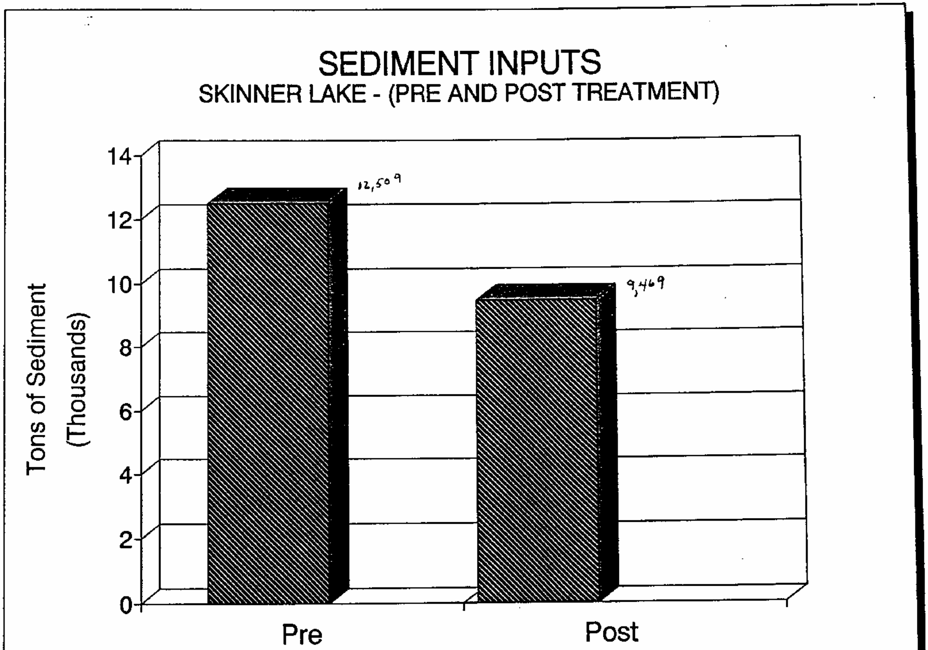


Figure 2. Sediment inputs to Skinner Lake (pre-BMP and post-BMP).

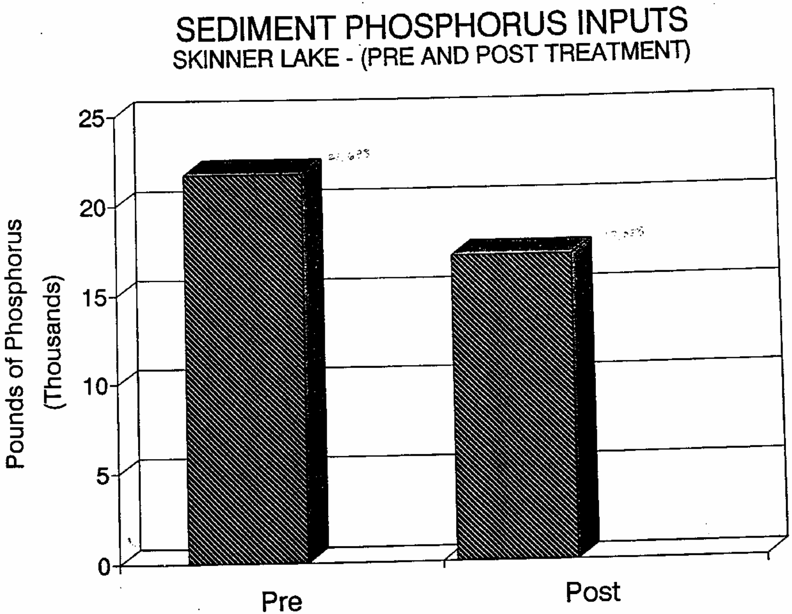


Figure 3. Sediment-bound phosphorus inputs to Skinner Lake (pre-BMP and post-BMP).

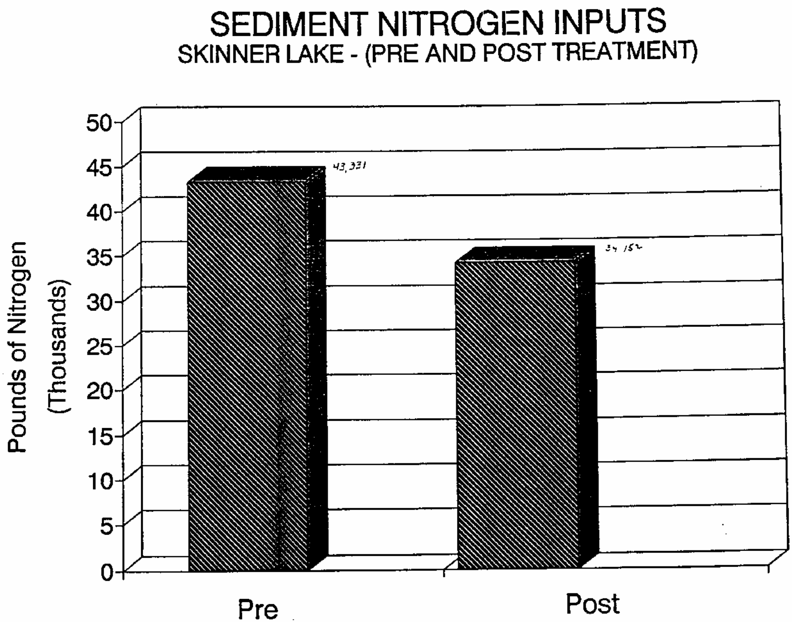


Figure 4. Sediment-bound nitrogen inputs to Skinner Lake (pre-BMP and post-BMP).

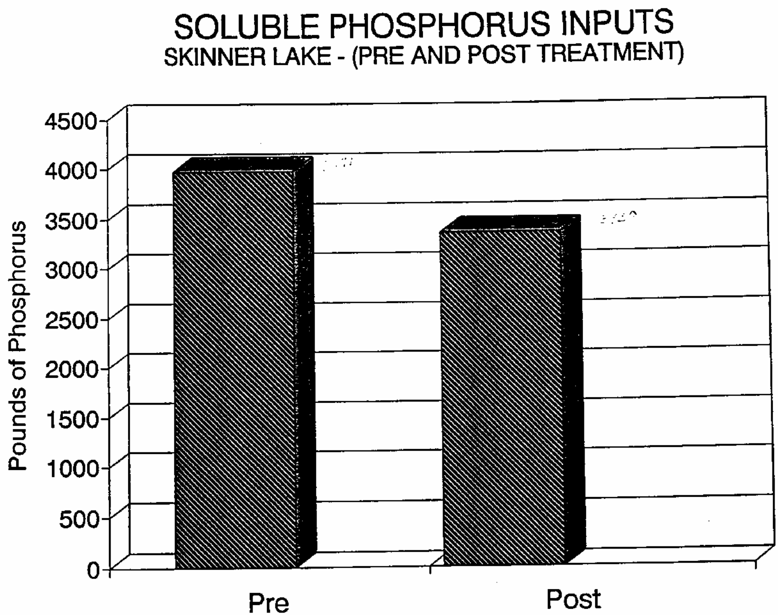


Figure 5. Soluble phosphorus inputs to Skinner Lake (pre-BMP and post-BMP).

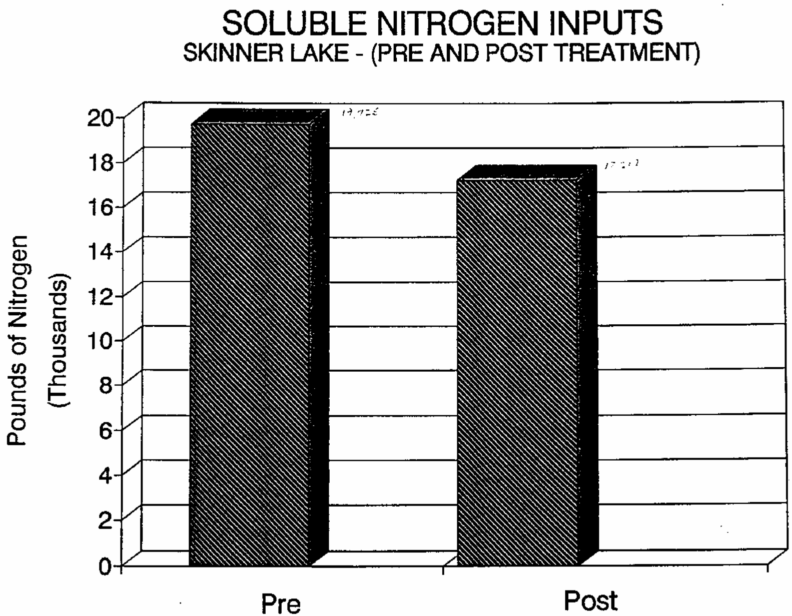


Figure 6. Soluble nitrogen inputs to Skinner Lake (pre-BMP and post-BMP).

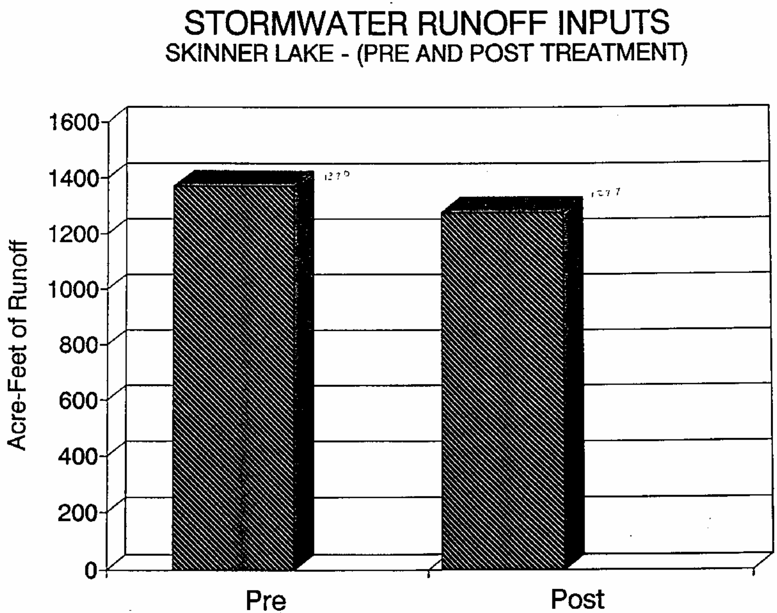


Figure 7. Stormwater runoff inputs to Skinner Lake (pre-BMP and post-BMP).

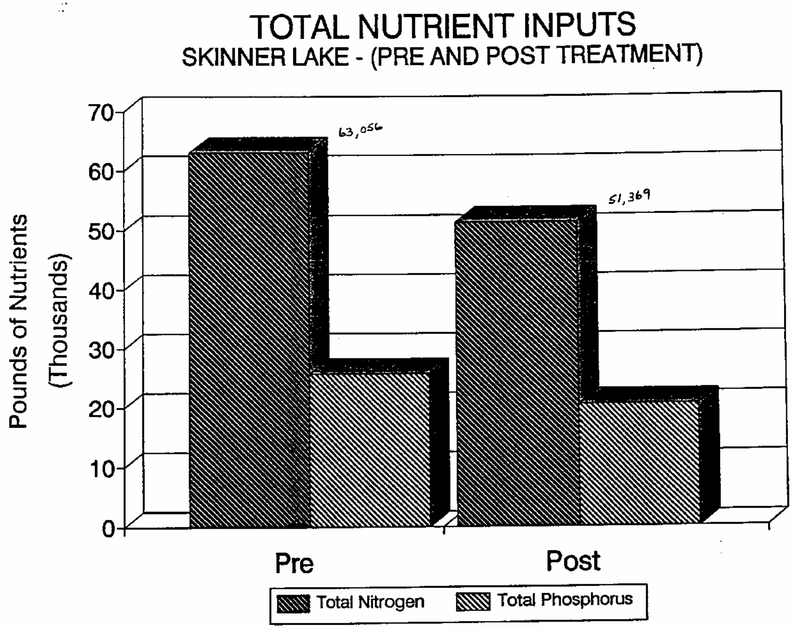


Figure 8. Total nutrient inputs to Skinner Lake (pre-BMP and post-BMP).

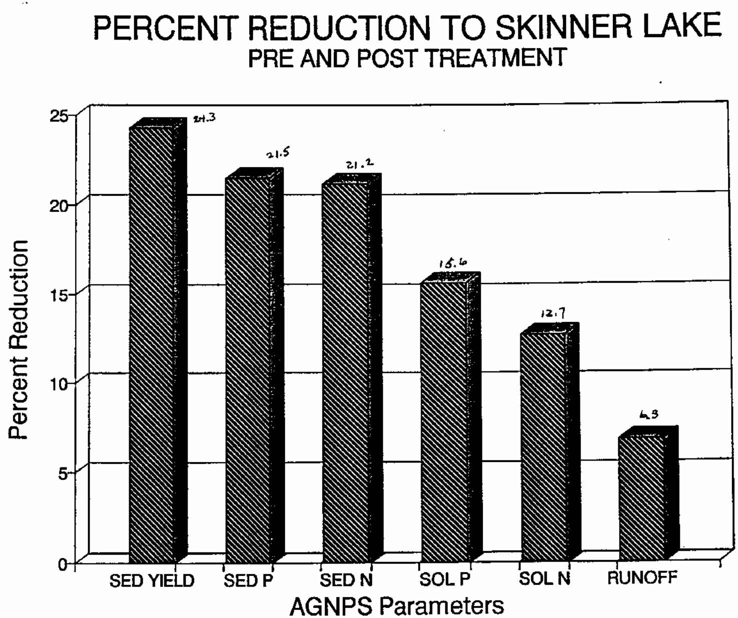


Figure 9. Percent reduction of inputs to Skinner Lake following BMP implementation.

Sediment inputs to Skinner Lake decreased from 12,508 to 9,468 tons or a 24% reduction. Most all of the land treatment measures installed in the watershed were aimed at reducing sediment. These measures are quite effective at reducing sediment. Figure 2 Sediment yield results did show the biggest percent change. (Figure 9)

Sediment phosphorus is phosphorus that is absorbed or incorporated into inorganic or organic particles. When sediment yield is reduced sediment phosphorus is also reduced. Sediment phosphorus was reduced from 21,697.9 lbs to 17,037.7 lbs or a 21.48% reduction. (Figure 3)

Sediment nitrogen also showed decreased levels do to controlling soil erosion. Sediment nitrogen was reduced from 43,330.9 lbs to 34,152.4 lbs a 21.18% reduction. (Figure 4)

Soluble phosphorus, the dissolved form of phosphorus was reduced from 3,970.6 lbs to 3,349.8 lbs a 15.63% reduction. (Figure 5). Since most land treatment practices concentrated on preventing soil erosion a greater reduction in sediment phosphorus was seen. Phosphorus is normally the limiting factor in algae growth and therefore should be of great concern.

Soluble nitrogen was reduced from 19,725.1 lbs to 17217 lbs or a 12.72% reduction. (Figure 6). Nitrogen is easily soluble, therefore since most practices reduced soil erosion, nitrogen could still be delivered to the lake in the soluble form.

Runoff was measured in acre feet. A reduction from 1,370.1 acre-ft to 1,276.6 acre-ft or a 6.83% reduction was seen in runoff. (Figure 7)

Total nutrient reductions (phosphorus and nitrogen) are noted in Figure 8. Both nutrients were significantly reduced by 20%. Most land treatment measures were installed to reduce soil erosion. Nutrient management along with further soil erosion control would most likely increase the percent reduction.

The AGNPS model runoff of the post treatment showed several "hot spot" cells. The cells with the highest export value of sediment bound nutrients were 83, 12 and 20. The highest cells with soluble nutrients were cells 20, 83 and 71. These areas should be examined for further land treatment activities. See Figure 10 to locate these cells.

SUMMARY

The land treatment program has been successful at reducing sediment loadings and delivery of attached nutrients as compared to the pre-treatment period. Soluble nutrients were not reduced as much as the sediment bound nutrients. This result is likely the product of a land treatment program focused on sediment reduction. Although reducing sediment also reduces sediment bound nutrients a nutrient management program would further help to control soluble nutrients from entering the lake.

The AGNPS program was effective in pointing out the need for sediment and nutrient management in the watershed. The AGNPS program is only as good as the information entered into the program. Most all the data was considered to be very accurate and the results were also considered to be accurate. The AGNPS model can be a valuable watershed management tool for predicting sediment and nutrient impacts during single storm events.

Literature Cited:

Pearson, Jed. 1980. The Effects of Watershed Improvement Practices on the Fish Community at Skinner Lake 1-3. Indiana Department of Natural Resources, Indianapolis, Indiana.

Young, Robert A., Charles A. Onstad, David D. Bosch, and Wayne P. Anderson. AGNPS, Agricultural Non-Point-Source Pollution Model. A Watershed Analysis Tool. 1987. U.S. Department of Agriculture, Conservation Research Report 35, 80 p.